twenty minutes or so, the condition of scotopia or twilight vision is developed, in which the retinal sensibility is enormously increased; it will now be found that if the illumination be very low the eye is absolutely colour blind. The curve of luminosity in such an achromatic scotopic eye is practically identical with the luminosity curve of the spectrum in any colour-blind person (p. 53), the brightest part of the spectrum being near the E line (530 $\mu\mu$) instead of near the D line (580 $\mu\mu$) as in the normal eye.

The phenomena of simultaneous and successive contrast and fatigue are dealt with in pp. 100-129, and then there follows an interesting account of the researches on the discrimination of colour by various animals and by primitive races. Conclusions about both of these must necessarily be indefinite. With regard to the latter, the mural decorations of ancient Egypt show that the sense of colour for red, yellow, green, and blue was well developed five or six thousand years ago.

Limits of space forbid a review of Part iii. on the various theories of colour vision: the duplicity theory—that the cones are the seat of impulses that lead to colour perception, while the rods are only influenced by light stimuli; the three components theory (Young, Helmholtz); the three opponents theory (Hering); and seven other theories are described and criticised with justice and judgment. The author is to be congratulated on producing a work that contains an immense amount of information with a good bibliography on the subject. He has given us an excellent general and unbiassed view of the facts and theories of colour vision.

THE EXPERIMENTAL METHOD IN MEDICINE AND SURGERY.

Animal Experimentation and Medical Progress. By Prof. W. W. Keen. With an introduction by Dr. Charles W. Eliot. Pp. xxvi+312. (Boston and New York: Houghton Mifflin Company, 1914.) Price 7*s*. 6*d*. net.

IN America there are very few surgeons more eminent, more beneficent, or more widely beloved than Prof. Keen. He fulfils and represents the very highest traditions of American surgery. He has done great things in practice, and in teaching, and in writing; and his name is held in reverence by doctors and surgeons over here. So, when he writes a book for general reading on a medical subject, the general reader had better read it: especially as it has an introduction from Dr. Charles W. Eliot, sometime president of Harvard University. Besides, the book is admirably written, full of learning, full of sympathy, full of a thousand facts touching man's daily welfare.

It is a justification, and more than justification, of experiments on animals for the advancement of the science and art of medicine and surgery. Prof. Keen is one of those leaders of his profession who are very sensitive to the brutal abuse and false witness of the "anti-vivisectionists." Whether it is wise to care so much what they say, each man must settle for himself. Anyhow, Prof. Keen does care very much indeed. He takes it to heart that these wild people are set to insult the medical profession, to give the lie to plain facts, and to attack with virulent language the very methods which they themselves take advantage of when they are ill. These people seem to be just as unkind and untruthful in America as they are here. Indeed, we are having a rest from them here, since the war began; except that some of them are trying to stop our soldiers from being protected against typhoid fever. It will be a grand thing, after the war, if we can keep anti-vivisection down, and give ourselves to worthier pursuits.

The book is a collection of essays, from 1885 to 1913, on the debt which mankind and the animal world owe to experiments on animals; and on the character and the attitude of anti-vivisection. The essays are complete, final, authoritative; they are the work of a master of surgery, a leader among surgeons. Where all are good it is hard to prefer one before another. Among those essays which review the benefits gained from experiments on animals, nothing could be better than "Recent Progress in Surgery," "Vivisection and Brain-Surgery," and "What Vivisection has done for Humanity." Among those essays which review the moral obliquity of anti-vivisection, nothing could be better than "The Influence of Anti-vivisection on Character," and "The Anti-vivisection Exhibition in Philadelphia in 1914." These two essays are masterpieces; they are gentle, quiet, courteous; but they expose a state of mind, in some American women, which is not pleasant to contemplate. Things were bad enough here, up to last August; but they seem even worse in New York.

Indeed, that is one of the strongest arguments against anti-vivisection—that it tends, unless it be held under self-control, to such amazing dishonesty, such greedy willingness to believe evil of other men, such loss of the sense of responsibility and of restraint.

But these faults, after all, are not the main theme of the book: and the work of nailing lies to counters is less important to us than the work of setting forth the great discoveries of medical and

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surgical science and art, especially those discoveries which have been made within the last half-century. These chapters of history are as good as good can be, and here is a book full of good reading, written by one of the chief of living surgeons.

Stephen Paget.

PURE MATHEMATICS.

(1) *A Treatise on the Analytic Geometry of Three Dimensions.* Fifth Edition. Vol. xi. By Dr. G. Salmon. Pp. xvi + 334. (London: Longmans, Green and Co., 1915.) Price 7*s*. 6*d*. net.

(2) *A Course of Pure Mathematics.* By G. H. Hardy. Second Edition. Pp. xii + 442. (Cambridge: At the University Press, 1914.) Price 12*s*. net.

(3) *Proceedings of the London Mathematical Society.* Second Series. Volume xiii. Pp. liii + 500. (London: Francis Hodgson, 1914.) Price 25*s*.

(1) IT cannot have been an easy task to prepare the new edition of Salmon's classical treatise; the result may be considered quite satisfactory, although, no doubt, different readers will form different opinions about the choice of additions that has been made. In this volume, the principal ones are as follows:—First of all, a considerable addition has been made to the section on line-geometry. So far as we can judge, this has been very well done; it includes Ribaucour's theory of isotropic congruences, a good deal about normal congruences, and other interesting matter. Next, and partly connected with the foregoing, we have an account of curvilinear co-ordinates, triply orthogonal systems, and cyclides; also other theorems due to Ribaucour.

In the part dealing with cubic and quartic surfaces, there is a sketch of Segre's analysis of the singularities of cubics; Geiser's correspondence of lines on a cubic with bitangents of a plane quartic; and some very good articles on cyclides, and the special quartics of Steiner and Kummer. Towards the end of the book, we have eight pages or so on birational transformations, with some useful references, and a revised table of singularities, mainly based on Zeuthen's memoir of 1876 (*Math. Ann.*, x.). This last does not seem to be quite up to date; for instance, no reference has been made to the work of Enriques and Castelnuovo, and their discussion of the deficiency of a surface, which has yielded a new fundamental characteristic, besides that called the deficiency in this book.

Reference is made (Art. 527*a*) to some recent work on the reduction of a cubic to the canonical form $\sum_{1}^{5} x_i^3 = 0$, and the proof that this is unique. One way of doing this is to obtain the equation $\Pi x_i = 0$, by a combination of invariants and covariants; this the present writer succeeded in doing a good while ago, with the help of Salmon's list of invariants, but the result was unpleasantly long.

Perhaps the most striking omission in the revised work is that of the theory of minimal surfaces. It would not have taken very many pages to give a fair account of this elegant theory, now that Lie and Weierstrass have reduced it to its simplest form. However, it may fairly be said that a student who has this work, and Prof. Forsyth's "Differential Geometry," will be able to make acquaintance with all the most important divisions of the subject, and be able to follow up any one in which he is specially interested.

(2) It is gratifying to see that Mr. Hardy's excellent treatise has so soon reached a second edition; and it helps to justify the statement in the preface that "it is no longer necessary to apologise for treating mathematical analysis as a serious subject worthy of study for its own sake." The author combines, in a remarkable way, strictness of method with an agreeable style; and his choice of topics seem to us to be eminently judicious. The principal additions in this re-issue are an account of Dedekind's theory of irrational numbers; a proof of Weierstrass's theorem about points of condensation, of the Heine-Borel theorem, and of Heine's theorem about uniform convergence; the notions of "limits of indetermination" and "implicit function" are also discussed. To save space, some analytical geometry and trigonometry has been deleted. The examples are well chosen, and hints towards solution are frequently given. This book, and Mr. Bromwich's "Infinite Series," to which Mr. Hardy refers in his preface, ought to do a great deal towards making school and college mathematics more rigorous, without making it repulsive; on the contrary, the apparent paradoxes explained, and the latent fallacies exposed, ought to provide a certain amount of fun, even for an undergraduate.

There are one or two very trifling points that may be noticed. On page 231, $D^{-1}(x^{-1})$, when x is negative, is defined as $\log(-x)$. This is very artificial, especially as the figure, page 359, implies that $\log x$ is undefined when x is negative. The same complaint of artificiality applies to the treatment of differentials (page 280). A rather more important point is on the proof (page 313) that the sum of a series of positive terms is the same "in whatever order the terms are taken."

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